

CLAIMS

1 A composition comprising a material having an average particle size of less than about 100 nm wherein the material, when heated to 700°C, retains an average surface area of at least about 100 m²/g.

2 A composition as in claim 1, the material having an average particle size of less than about 50 nm wherein the material, when heated to 700°C, retains an average surface area of at least about 150 m²/g.

3 A composition as in claim 1, the material having an average particle size of less than about 25 nm wherein the material, when heated to 700°C, retains an average surface area of at least about 200 m²/g.

4 A composition as in claim 1, the material having an average particle size of less than about 10 nm wherein the material, when heated to 700°C, retains an average surface area of at least about 300 m²/g.

5 A composition as in claim 1, the material having an average particle size of less than about 5 nm wherein the material, when heated to 700°C, retains an average surface area of at least about 400 m²/g.

6 A composition as in claim 1, wherein the material is a ceramic material.

7 A composition as in claim 1, wherein the material is a metal oxide selected from the group consisting of Group IA metal oxides, Group IIA metal oxides, Group IIIA metal oxides, transition metal oxides, an oxide of a metalloid, an oxide of a semimetal, an oxide of a lanthanide, an oxide of an actinide and combinations thereof.

8 A composition as in claim 7, wherein the metal oxide is selected from the group consisting of magnesia, calcia, baria, titania, manganese oxide, yttria, zirconia, lanthana,

ceria, samaria and combinations thereof.

9 A composition as in claim 7, wherein the oxide is a complex metal oxide having at least two metal types.

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10 10 A composition as in claim 9, wherein the complex metal oxide is selected from the group consisting of a perovskite, an aluminat, titanate, silicate and combinations thereof.

11 11 A composition as in claim 10, wherein the complex metal oxide is selected from the group consisting of La-Sr-Fe-Co oxide, barium hexaaluminate, strontium hexaaluminate and strontium titanate.

12 12 A composition as in claim 1, wherein the material comprises at least one metal oxide doped with at least one metal oxide.

13 13 A composition as in claim 1, wherein the material comprises at least one metal oxide supported on at least one metal oxide.

14 14 A composition as in claim 1, wherein the material is immobilized on a surface of a monolith.

15 15 A composition as in claim 1, wherein the material retains an average surface area of at least about 300 m²/g at room temperature.

25 16 16 A composition as in claim 1, wherein the material, when heated to at least 500°C, retains an average surface area of at least about 100 m²/g.

17 17 A composition as in claim 1, wherein the material, when heated to at least 900°C, retains an average surface area of at least about 100 m²/g.

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18 18 A composition as in claim 1, wherein the material, when heated to at least 1100°C,

retains an average surface area of at least about 20 m²/g.

19 A composition as in claim 1, wherein the material, when heated to at least 1300°C, retains an average surface area of at least about 20 m²/g.

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20 A composition comprising:

a material capable of catalyzing a combustion reaction of a hydrocarbon, the material having an average surface area, after exposure to conditions of at least about 1300°C for at least about 2 hours, of at least 20 m²/g.

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21 A method comprising effecting a reaction via introducing a water-reactive reactant in the presence of a reverse emulsion and recovering a material from the reaction having an average particle size of less than about 100 nm wherein the material, upon exposure to 700°C for at least about 10 mins., retains a surface area of at least about 100 m²/g.

22 A method as in claim 21, wherein the step of introducing the reactant comprises introducing a ceramic precursor into the reverse emulsion prior to reaction.

23 A method as in claim 54, wherein the step of introducing the ceramic precursor into the reverse emulsion comprises dissolving the ceramic precursor in a solvent that is miscible with a continuous phase of the emulsion.

24 A method as in claim 54, wherein the ceramic precursor is miscible with a continuous phase of the emulsion.

25 A method as in claim 54, comprising introducing the ceramic precursor into a discontinuous phase of the emulsion prior to reaction.

26 A method as in claim 21, comprising introducing a ceramic precursor in a non-aqueous emulsion into the reverse emulsion.

27 A method as in claim 54, comprising introducing a ceramic precursor into an aqueous phase of the reverse emulsion prior to formation of the emulsion.

28 A method as in claim 54, comprising effecting the reaction by applying energy from an energy source to reactants in the presence of the reverse emulsion.

5 29 A method as in claim 28, wherein the energy source is selected from a group consisting of a microwave radiation source, a laser, an ultraviolet radiation source, and an electric, magnetic, or electromagnetic field.

10 30 A method as in claim 54, comprising recovering particulate product by inducing phase separation of the reverse emulsion by a process selected from the group consisting of cooling and heating.

15 31 A method as in claim 54, comprising recovering particulate product by spray-freezing the reverse emulsion.

32 A method as in claim 54, comprising recovering particulate product after aging.

20 33 A method as in claim 22, wherein the ceramic precursor comprises an alkoxide.

34 A method as in claim 54, wherein the reverse emulsion contains from about 1 to about 40 wt% water.

25 35 A method for preparing a particle, comprising:
providing an emulsion including a hydrocarbon, at least one surfactant and a water content of about 1-40% to form reverse micelles, the reverse micelles comprising a disperse aqueous phase;
adding at least one water-reactive reactant; and

allowing the at least one reactant to react in and with the disperse aqueous phase to form a particle having a particle size of less than about 100 nm, the particle being free from agglomeration.

5 36 A method as in claim 59, wherein the surfactant is a non-ionic surfactant.

37 A method as in claim 59, further comprising adding a base prior to reaction in and with the disperse aqueous phase.

10 38 A method as in claim 59, wherein the particle has an average surface area of at least 20 m²/g.

39 A method as in claim 35, wherein the particle is a metal oxide particle.

15 40 A method as in claim 39, wherein the metal oxide particle is a mixed metal oxide particle comprising at least two metals.

41 A method for preparing a particle, comprising:
providing an emulsion including a hydrocarbon, at least one non-ionic surfactant and
20 a water content of about 1-40% to form reverse micelles, the reverse micelles comprising a disperse aqueous phase;
adding at least one reactant; and
forming a particle having a particle size of less than about 100 nm, the particle being free from agglomeration.

25 42 A method comprising coating a particle within a micelle.

43 A method as in claim 42, wherein the particle is coated with a metal oxide layer.

30 44 A method as in claim 42, wherein the micelle is a reverse micelle.

45 A method as in claim 42, wherein the particle is a metal oxide particle.

46 A method comprising:

5 providing a composition having a surface area of at least 20 m²/g after exposure to conditions of at least 1300 °C for at least 2 h; and oxidizing a hydrocarbon.

47 A method as in claim 46, wherein the composition comprises particles having a particle size of less than about 100 nm.

10 48 A method as in claim 46, wherein the hydrocarbon is selected from the group consisting of methane, ethane, propane and butane.

15 49 A method as in claim 46, wherein conversion of the hydrocarbon is at least 10 % at 400 °C.

50 A method as in claim 49, wherein at least 90% of the conversion is sustained at 1100 °C for at least 2h.

20 51 A method comprising oxidizing at least one hydrocarbon in the presence of at least one non-noble metal oxide having a particle size of less than about 100 nm.

52 A method as in claim 51, wherein the metal oxide has a surface area of at least about 20 m²/g.

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53. A method as in claim 33, wherein the alkoxide comprises barium alkoxide.

54. A method comprising:

30 introducing a water-reactive reactant comprising a ceramic precursor including barium alkoxide and aluminum alkoxide in the presence of a reverse emulsion; effecting a reaction; and

recovering a material from the reaction having an average particle size of less than about 100 nm wherein the material, upon exposure to 700°C for at least about 10 min., retains a surface area of at least 100 m²/g.

5 55. A method as in claim 54, wherein the recovered material comprises barium hexaaluminate.

10 56. A method as in claim 35, wherein the water-reactive reactant comprises a ceramic precursor.

15 57. A method as in claim 56, wherein the ceramic precursor comprises an alkoxide.

58. A method as in claim 57, wherein the alkoxide comprises barium alkoxide.

20 59. A method for preparing a particle, comprising:
providing an emulsion including a hydrocarbon, at least one surfactant and a water content of about 1-40% to form reverse micelles, the reverse micelles comprising a disperse aqueous phase;
adding water-reactive reactants comprising barium alkoxide and aluminum alkoxide;
and
allowing the water-reactive reactants to react in and with the disperse aqueous phase to form a particle having a particle size of less than about 100 nm, the particle being free from agglomeration.

25 60. A method as in claim 59, wherein the particle comprises barium hexaaluminate.

30 61. A method as in claim 54, wherein the recovering step comprises recovering a material from the reaction having an average particle size of less than about 50 nm wherein the material, upon exposure to 700°C for at least about 10 min., retains a surface area of at least about 150 m²/g.

62. A method as in claim 54, wherein the recovering step comprises recovering a material from the reaction having an average particle size of less than about 25 nm wherein the material, upon exposure to 700°C for at least about 10 min., retains a surface area of at least about 200 m²/g.

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63. A method as in claim 54, wherein the recovering step comprises recovering a material from the reaction having an average particle size of less than about 10 nm wherein the material, upon exposure to 700°C for at least about 10 min., retains a surface area of at least about 300 m²/g.

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64. A method as in claim 54, wherein the recovering step comprises recovering a material from the reaction having an average particle size of less than about 5 nm wherein the material, upon exposure to 700°C for at least about 10 min., retains a surface area of at least about 400 m²/g.

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65. A method as in claim 54, wherein the recovering step comprises recovering a material from the reaction having an average particle size of less than about 50 nm wherein the material, upon exposure to 900°C for at least about 10 min., retains a surface area of at least about 100 m²/g.

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66. A method as in claim 54, wherein the recovering step comprises recovering a material from the reaction having an average particle size of less than about 50 nm wherein the material, upon exposure to 1100°C for at least about 10 min., retains a surface area of at least about 100 m²/g.

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67. A method as in claim 54, wherein the recovering step comprises recovering a material from the reaction having an average particle size of less than about 50 nm wherein the material, upon exposure to 1300°C for at least about 10 min., retains a surface area of at least about 100 m²/g.

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68. A method as in claim 54, wherein the recovering step comprises recovering a

material from the reaction having an average particle size of less than about 50 nm wherein the material, upon exposure to 1300°C for at least about 2 hours, retains a surface area of at least about 100 m²/g.

5 69. A method as in claim 59, wherein the surfactant is a non-ionic surfactant.

70. A method as in claim 59, wherein the particle is coated with a metal oxide layer.

71. A method as in claim 59, wherein the particle is a metal oxide particle.

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